

Summary of Report on Travel to the International Committee for Future Accelerators Workshop on 4th Generation Light Sources.

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Purpose: To attend the ICFA Workshop on 4th Generation Light Sources.

Abstract: The purpose of the workshop was to discuss how one would design light sources (i.e. synchrotron radiation sources) with an improved beam quality over the present light sources. Many working groups at the workshop were formed. I participated in the group discussing storage ring lattice designs for lower emittances. The goals of the working group turned out to be more modest than I expected. I had expected the group to talk about a proposal to build a X-ray diffraction limited source, instead they concentrated on a VUV-diffraction limited source or a VUV source whose photon brightness only “approaches” that of a VUV diffraction limited source. The design of a VUV diffraction limited source is much less demanding than those of an X-ray diffraction limited source. However, I had been under the impression that synchrotron light users preferred a X-ray diffraction limited source to a VUV diffraction limited source. The report presents some topics of interest to the group, and my ideas on a X-ray diffraction limited source.

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1 Purpose

The purpose of the workshop was to discuss how one would design light sources (i.e. synchrotron radiation sources) with an improved beam quality over the present light sources. The program committee organized the workshop in seven working groups:

- Scientific opportunities for 4th generation light sources : VUV/soft x-rays
- Scientific opportunities for 4th generation light sources : hard x-rays
- Lattice and stability in storage rings
- Current, lifetime, time structure in storage rings
- Linac sources
- Storage Ring FELs
- Insertion devices

The participants were given the choice of which working group to join. I selected the working group “Lattice and stability in storage rings”, since I had experience in designing low-emittance rings.

On the first day, we had a plenary session where the leader of each working group gave a 20 minute review talk on their subject. There were summary of previous workshops, those of the Fourth Generation Light Sources at Stanford in 1992, and the Microbunch workshop at the National Synchrotron Light Source at Brookhaven in 1995.

The working groups met separately on the second and third day. Short summaries of the working group discussions were given at the end of each days. Conclusions of each working groups were given in a plenary session on the fourth day.

2 Activity of working group “Lattice and stability in storage rings”

This is the working group I attended. The meetings covered experimental results, operational issues, and lattice design. I’ll concentrate more on lattice design since this is what DOE might be more interested in. The complete list of topics will be available in the proceedings. Though the following basic ideas for low-emittance rings have been around for years, they are applied here to specific designs. There are three approaches to reducing the beam emittance:

1. Reducing the energy of the beam, and increasing the circumference of the ring, while keeping the basic focusing cell of the ring the same.

This is ESRF's approach to the design 4th generation sources (speaker A. Ropert from ESRF) which starts from the design of the existing ESRF ring. A practical lower limit is reached in the beam emittance because of the higher density of particles inside each bunch which increases the number of collisions between particles (intra-beam scattering) which then tend to increase the beam size, defeating our goal. The problem here is that the natural synchrotron radiation damping is reduced at the same time as the emittance. Using only this idea we are stuck.

2. Inserting damping (i.e. strong) wigglers in the lattice.

This is how KEK laboratory reduced the emittance of an existing ring (TRISTAN at KEK) by 30%, a modest amount (speaker S. Kamada from KEK). This approach is less sensitive to the intra-beam scattering mentioned above. This method is easily scalable to larger emittance reduction, simply by installing more wigglers. All it takes is more money. There doesn't seem to be technical problems with this method.

3. Modify focusing cells by increasing the overall focusing and reducing the distance between magnets.

This method has received a great deal of attention at the workshop. Curiously, there was a concern in making the circumference of the machine not too large or too different from an existing machine. The feeling is that any funding organization might be "scared off" by the cost associated to the number of magnets, or of building a new tunnel. Presentations were made by Y. Cho from ANL, and D. Einfeld from Fachhochschule Ostfriesland, Germany. The technical problem here is that lattice non-linearities increase substantially, and some lower limit in emittance is achieved when the minimum stable phase space area for beam injection is at risk.

A topic related to the stable injection phase space area is an injection method which reduces the beam injection oscillations by half, and therefore relieves some injection concerns (speaker U. Weinrich of ESRF). Another idea, which requires much less stable phase space area, is that of simply injecting beam on-axis and toping-off by replacing a few bunches of the old beam with new bunches of slightly higher charge.

Emittances achieved in these presentations are suitable for a VUV diffraction limited light source, but not for an X-ray diffraction limited light source, which is where the real interest in the user community lie.

During the presentations of the above, I mentioned a few times my own Ph.D. thesis work which combines most of the above ideas in one design of a 2-km circumference and 4-GeV high-energy linear collider damping ring adaptable to an X-ray diffraction limited light source. This work was presented at the 1992 4th Generation Light Source Workshop, and published in the proceedings.

The basic idea is that some straight sections in the storage ring should be filled with very long and strong wigglers that will provide practically all of the damping. Damping reduces the emittance, and reduces the susceptibility of intra-beam scattering. Very short cells specially designed for reduced non-linearities and low emittance contribution can be used in the arcs to bring the beam around to the next wiggler. Thus one can get very low emittance and surprisingly large stable area for beam injection. Criticism of my design was

not technical in nature, but rather financial. The working group members believed that it was too expensive to build or even to propose to a governmental agency in the future, although no one, including me, have made a cost estimate.

I agree that a large ring with lots of wigglers would be more expensive, in the same way a sports car is more expensive than a mass-produced car, but I know of no other design ideas (for a storage ring) that come even close to a X-ray diffraction limited light source as mine does. The combination of ideas in my design appeared to interest only one other member of the group, and was mentioned only briefly in the working group summaries on the last day.

It is my opinion that there are sufficient number of light sources in the world. A dirty little secret is that VUV sources are under-subscribed. If there is a demand for a diffraction limited light source among users, my guess is that an X-ray source will be much more valuable than a VUV source.

2.1 Other activities unrelated to the workshop

- I had a chance to visit the ESRF facility. I'm happy to report that our equivalent facility, APS, has a better appearance than ESRF. The physical plant at APS, i.e. the concrete tunnel, the experimental area, the magnet construction, cable trays, air conditioning ducts, and other small details, are all better looking either through better workmanship or better selection of material or equipment. The ESRF control room has a couple of electronics cabinets installed permanently right in the middle of the floor, just like in the old days! The lobby of the office building is decorated with tall plants, transparent elevator cars, and suspended staircases with a sloping bottom landing that I've almost tripped on, all of this creating the bizarre look of a miniature hotel lobby. These are certainly superficial observations, but a visitor comparing both facilities can only be more impressed by APS.
- I discussed the accelerator physics methods (this is my area at APS) used by our counterparts at ESRF. I must say that we are ahead of them in many areas, a significant statement considering that they have two years of experience ahead of us. I attribute this in part to our selection of the control system EPICS, to our toolkit approach of computer codes, and to our philosophy of collecting and processing data in a de-centralized and flexible way. In addition, I noted that their accelerator physics group is a little more bureaucratic than ours and utilize obstrusive division of labor (i.e. the person running simulation codes isn't the same one who analyses the results). As I implied above, I found them less sophisticated in the use of computers than we are. I tried to explain to some the way we did things at APS, and told them they might benefit from the ideas we developed at APS, but I left them unimpressed. In summary I wasn't able to bring back from this trip any new knowledge in doing accelerator physics.

Appendix to Report on Travel to the International Committee for Future Accelerators Workshop on 4th Generation Light Sources.

- France's economy is a joke. The first thing I noticed (as I've noticed in other European countries) was that automobiles were tiny and gutless. Gas is \$6/gallon, most of it tax, since the world market price of gas is about 55 cents/gallon. How can life be enjoyed there?

With what I know of the cause and effect relation of economics and government policy, it is clear that the U.S. government should not emulate anything the French government does. No doubt, because of protectionist policies, I found consumer items in France much more expensive than in the U.S. Food is twice as expensive. In fine restaurants, the red meat and poultry was very tough, though not as tough as the steaks at my sister-in-law's last barbecue. However I must praise the restaurants' attention to details and the choice of other types of foods. I read in a French paper that a new 0.5 % payroll tax will commence in February, this tax supposedly used to reduce their government's debt. I view this as nothing more than a gimmick to extract more money out of French working people.

In my political discussions with French people (I speak French), I found none understood the functioning and the desirability of free markets, and the benefits of less government interference in one's life. This is ironic since the expression "Laissez Faire" was coined in France, and many historical free-thinkers were born in France.

I feel extremely fortunate that my 17th century French ancestors decided to settle in Canada, which then gave me the opportunity to live and prosper and drive a gas-guzzling sports car in the United States.